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NUMERICAL SIMULATION OF THE COLLAPSE OF AN UNDERWATER EXPLOSION BUBBLE

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Final Technical Report on

Numerical Simulation of the Collapse

of an Underwater Explosion Bubble

ONR Contract N00014-87-K-0428

Purpose: The goal of this project was to demonstrate the usefulness of front tracking (J. Glimm, et. al., Courant Institute, NYU) as a tool for studying the fully compressible, axially symmetric expansion and collapse of an underwater explosion bubble in two spatial dimensions. In the pilot project supported by this contract, a one dimensional version of the front tracking code was implemented to compute spherically symmetric oscillations.

Final status and conclusions: A one dimensional, tracked random choice code [1] was adapted for this pilot project, and validated against published computational and experimental results. Specifically, comparisons were made with untracked, random choice calculations by Saito and Glass [2] and Flores and Holt [3] and by calculations of Mader [4] using the code SIN. These validation studies were presented in the Appendix to the previously submitted Annual Report for 1987 for this contract. A copy of this annual report is enclosed.

These validation studies identified several improvements required by the tracked algorithm. These included 1) the necessity for realistic equations of state for the explosion products (stiffened gamma law gas equations of state where used in the study), 2) the implementation of effective boundary conditions that would take into account the progress of the primary shock wave into the water without the necessity of keeping it within the computational domain, 3) improved treatment of the divergence at the bubble center, and 4) correct initiation (i.e. velocity profile) of the explosion remains.

Plans were formulated for overcoming each of these problem areas, and were discussed in the aforementioned annual report. Briefly they were: 1) implementation of the HOM equations of state, which were to be input to a Reimann problem solver developed for general tabulated equation of state data by J. Scheuerman at the Courant Institute, 2) using the ideas of T. Hagstrom [5] and others to achieve effective far field boundary conditions once the primary shock leaves the domain of computation. 3) investigating the analytical treatment of Noh as a possible method for handling the divergences at the bubble origin. 4) implementation of a model for the reactive phase of the explosion in one of the manners discussed by Mader [4].

This project was terminated at the end of the pilot project, when further research funding was discontinued. Other than the Appendix in the previously submitted annual report, no technical report or publication resulted from this project.

References

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4. C. Mader, *Numerical Modeling of Detonations*, University of California Press, Berkeley, California, 1979.

5. T. Hagstrom and S. I. Hariharan, "Accurate boundary conditions for exterior problems in gas dynamics", *Math. Comp.*, **51**, pp. 581-597, 1988.